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| 13. ABSTRACT (Maximum 200 words)<br><br>The necessary equipment for a two camera DPIV system was purchased. It included two cameras, two frame grabbers, a PC based computer, a laser and shutter, optics for the camera, optics for the laser, a workstation for computational processing, and control and signal conditioning electronics. A unique feature of this system is the utilization of special cameras which allow externally synchronized acquisition of two frames separated by only 1- 5 $\mu$ s, permitting cross-correlation PIV analysis for flows up to 250 m/s.<br><br>The DPIV system has been put together and tested in the Mark V. Morkovin wind tunnel at IIT. Comparison between the statistics of the resulting velocity field and earlier hot-wire measurements in the same wind tunnel reveals the ability of the new DPIV system to provide high spatial resolution measurements with high accuracy. The new system is currently being adapted for use in the National Diagnostic Facility (NDF) at IIT. |  |   |  |  |
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# **A PIV SYSTEM FOR TIME-RESOLVED MEASUREMENTS AT HIGH REYNOLDS NUMBERS IN THE NATIONAL DIAGNOSTIC FACILITY**

Final Technical Report  
June, 1997

AFOSR-F49620-95-1-0237

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### Abstract:

The necessary equipment for a two camera DPIV system was purchased. It included two cameras, two frame grabbers, a PC based computer, a laser and shutter, optics for the camera, optics for the laser, a workstation for computational processing, and control and signal conditioning electronics.

### Objectives:

Assemble a flexible Digital Particle Image Velocimetry (DPIV) System for measurement of high-speed air flows in the National Diagnostic Facility (NDF).

Photographic and Digital PIV have the capability of measuring two component of velocity simultaneously over a large field. A DPIV system provides quick feedback of results allowing better control of experimental parameters and collection of larger volumes of data. For time resolved measurements of high speed flows, advanced cameras and lasers are necessary to operate at the necessary high speeds.

### Equipment:

This grant was used to purchase a pair of Kodak ES1.0 cameras along with a pair of ICPCI/DIG frame grabbers from Imaging Technology. The Kodak cameras have a 1k by 1k pixel array and allow externally synchronized acquisition of two frames separated by only 1-5 microseconds (a unique feature). This permits a cross-correlation PIV analysis for flows up to 250 m/s with overall measurement regions of 2.5cm by 2.5cm. The cross-correlation analysis resolves directional ambiguity and gives higher measurement accuracy. Use of two camera will provide either stereoscopic views of the measurement plane or recording at consecutive times for time resolved measurements. The frame grabbers capture the digital output of the cameras for higher accuracy, and contain enough onboard memory for four frames. Both frame grabbers are installed in an industrial micro-computer (Micro Alliance Inc. - 233 MHertz Pentium Pro Processor ) with 256 megabytes of RAM, 4 gigabytes of hard disk space and a tape backup system. The PCI data bus has sufficient band width to transfer the images directly into memory expanding the number of consecutive acquisitions to 256 frames. The hard disk space and tape drive are required to handle the large volumes of data.

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This grant also was used to purchase a high power Ar-Ion Laser (Spectra Physics Lasers - Stabilite 2017) and a beam chopper (Vincent Associates - LS6Z2). The system is suitable for preliminary flow visualization and lower speed experiments. It also permits an existing pair of Nd-YAG to be exclusively dedicated to the NDF for PIV experiments.

An array of wide angle camera lenses was compiled for PIV application. Two Schneider 56 mm lenses and

one Nikkór 150mm lens (Calumet Photographic) were added to existing lenses at focal lengths of 150, 220, and 460 mm. The wide angle lenses are higher quality and more flexible in implementation than standard SLR camera lenses. Using an custom built assembly both cameras can be focused on the same region in flow space quite simply.

In addition, a large quantity of laser optics and optical mounts was purchased from Melles Griot and CVI Corporation. The items include lenses, a table, a He-Ne Laser for alignment, mirrors, mounts, and photo sensitive diodes for testing.

An additional Unix based workstation (Silicon Graphics - O<sub>2</sub> ) has been added for exclusive processing of DPIV data. The Unix platform is more stable for development of analysis software and the network integration provides more computing power during peak periods (i.e. the capability of using other FDRC computing facilities). An additional 4 gigabyte hard disk is attached to this system to handle the data load. A software package for data presentation was also purchased.

A number of pieces of support hardware has been added for use with DPIV experiments. A high speed digital oscilloscope (LeCroy ) was purchased for system debugging and data acquisition of simultaneous pressure or hotwire data. One major interest is the capability of recording simultaneous DPIV and pressure data. In addition two analog filters and an amplifier (DL Instruments), a DC power supply (Hewlett Packard), and a function generator (Stanford Research Systems) were purchased. This hardware allows for control of the lasers and the cameras with either a user defined frequency or from a filtered probe signal.

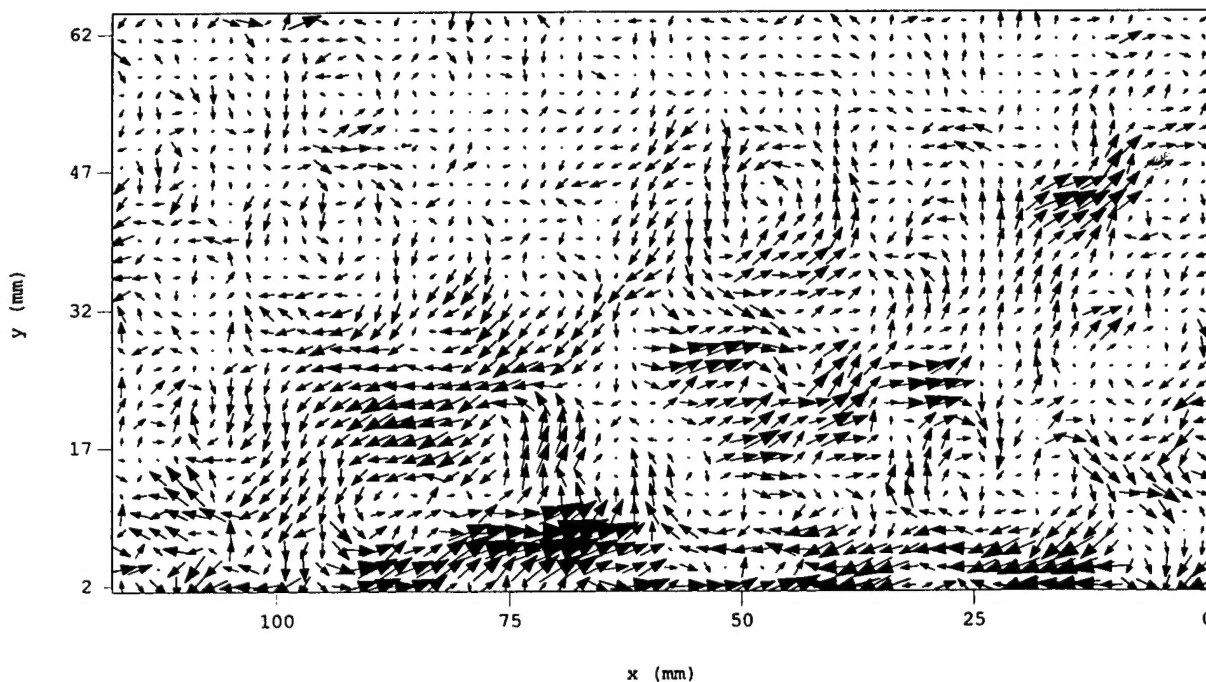
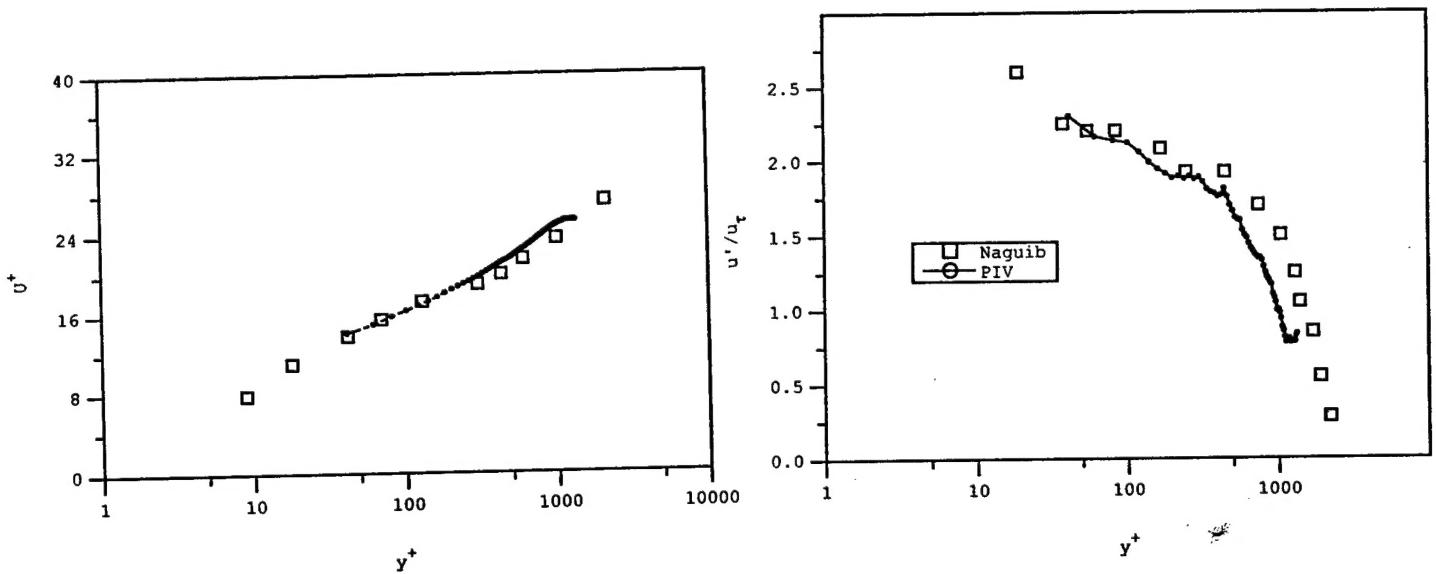


Figure 1: Velocity fluctuations, the boundary is located at  $y = 0$ , and freestream velocity is 12 m/s.

### Application:

Currently the system is still in the development stage. The new camera hardware has shown itself to be capable of providing high spatial resolution measurements with high accuracy. The application of both cameras to the NDF is still in progress.

Early results are shown in figures 1-3. The data corresponds to a boundary layer at  $Re_\theta = 4,000$ . Figure 1 shows the fluctuating velocity field in meters per second with the mean velocity profile removed ( $U_m = U_m(y)$ ). Figure 2 and 3 show the non-dimensionalized mean and RMS velocity profiles for 42 measurement fields. The data is compared with similar hotwire measurements taken by Naguib.



Figures 2 and 3: mean and fluctuating velocity profiles.